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BREEDING MILLET AND SORGO FOR DROUGHT ADAPTATION.

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INTRODUCTION.

In the course of investigations which have as their object the perfection of methods for testing the comparative drought resistance of crop plants and for breeding drought-resistant varieties, two strains of millet and one of sorgo have been developed. These strains give evidence of being more uniform, more productive, and better adapted to the climatic conditions of the north-central Great Plains than the varieties generally grown in that region. The object of the present publication is to point out those characteristics of the new strains which indicate their value to dry-land agriculture in the Great Plains region.[1]

THE PLACE OF MILLET AND SORGO IN THE AGRICULTURE OF THE GREAT PLAINS.

It is becoming more and more evident that successful farming in the Great Plains must include the raising of live stock. The established settlers in this region are those who have depended on live stock as their main source of income. In favorable seasons grain crops are profitable, but the profit from growing them can doubtless be increased if a portion of the grain is consumed on the farm as feed for animals. In the driest seasons, however, when small grains are likely to be a total failure, forage crops sufficient to carry animals through the winter can nearly always be depended on. This is because the most drought-resistant forage crops can be raised on a much smaller supply of moisture than the grain crops.

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[1] By cooperative arrangement with the Office of Forage-Crop Investigations these strains will be tested at numerous dry-land stations in comparison with other varieties of the same crops, in order that their relative merit and range of geographical adaptation may be fully ascertained. It seems desirable, however, to publish an account of them at this time, since they give every indication of being superior to the ordinary commercial varieties of sorgo and millet which are now grown in the northern portion of the Great Plains area.

The earlier results of these investigations have been reported in a previous publication, which also gives fuller details of the plant-breeding methods. See Dillman, A. C., Breeding drought-resistant forage plants for the Great Plains area, U. S. Dept Agr., Bur. Plant Indus. Bul. 196, 1910.

The native range is used to a large extent for summer pasturage, but it is necessary to produce under cultivation most of the forage for winter feeding, and it is often necessary to supplement the summer pasturage with cultivated crops. It is evident, therefore, that forage crops should occupy a very important place in the agriculture of the Great Plains.

In some sections of the northern Great Plains alfalfa, brome-grass, and other perennial crops give excellent results, but certain annual forage crops appear to be much more dependable in the central Plains. Two of the most suitable crops for this region are the millets and sorghums. Millets grow and mature in a comparatively short season and are often able to escape drought when other crops are overtaken. Sorghums endure drought well, standing a long period of drought and yet renewing growth upon the return of favorable conditions. Both crops have a very low water requirement.

ADAPTATIONS TO DROUGHT IN MILLET AND SORGO.

ROOT DEVELOPMENT.

Millet has a comparatively shallow root system with a great development of fine fibrous roots. It is therefore well adapted to make the best use of light rains which wet the soil to a depth of only a few inches. The early root growth is somewhat slow, so that the young plants are sometimes injured by high winds before the roots are well enough established to hold the plants firmly. Sorgo has a much deeper root system than millet and can apparently make use of moisture which is stored 3 or 4 feet deep in the soil. Both crops draw heavily upon the supply of soil moisture and are likely to use for their growth all of the water that is available in the area penetrated by their roots.

EARLY MATURITY.

The period of growth of the crop is of great importance under dry-land conditions. The ideal crop is one that will mature in a short season and therefore lessen the risk of being overtaken by drought. The short-season crop has the further advantage of allowing the soil to lie fallow for a considerable period of the year when moisture conservation may be practiced and the largest possible quantity of water stored in the soil for the use of the following crop. The strain of millet (Dakota Kursk) described in this bulletin may be cut for hay in from 70 to 75 days after planting and will mature seed in 90 days. The early strain of sorgo (Dakota Amber) described here matures seed in a period of 95 to 100 days from the date of planting and is sufficiently mature for forage in 15 days less time.

DROUGHT ENDURANCE.

The most important adaptation to drought presented by sorgo is its ability to revive quickly after a period of drought. The crop may cease growth for a considerable time during a dry period, but if a heavy rain occurs it will then revive and make a rapid growth. This was the case at Akron, Colo., in 1910, when a dry period during June and July allowed only a limited growth of the crop and caused the plants to produce seed heads earlier than usual. A rain of 2.8 inches on August 4, however, caused a vigorous secondary growth, so that the plants produced additional seed heads, which were fully two weeks later in maturing than the seed first formed.

Millet shows much less drought endurance than sorgo, but it compares favorably with the small grains and corn.

LOW WATER REQUIREMENT.

A low water requirement[1] is an important factor in the adaptation of plants to conditions of drought. In this respect millet and sorgo are preeminent among drought-resistant crops. At the Belle Fourche (S. Dak.) station in 1912 millet had a water requirement of 240, as compared with 460 for wheat and 735 for alfalfa; that is, the quantity of water which was required to produce 1 ton of dry matter (hay and grain) in a mature millet crop would produce only 1,043 pounds of dry matter (hay and grain) in the form of a mature wheat crop and only 654 pounds of dry matter in the form of alfalfa hay. In experiments conducted at Akron, Colo., Briggs and Shantz found that the water requirement of sorgo is only slightly higher than that of millet. The water requirement of millet and sorgo is further discussed elsewhere in this bulletin.

CLIMATIC CONDITIONS.

Crop production in the Great Plains is largely dependent upon the amount of rainfall which occurs during the growing season of the crop. By means of summer fallowing a part of the precipitation of one season may be stored in the soil for the benefit of the following crop, but the amount of moisture stored in this manner usually is not enough in itself to mature a crop, though it is oftentimes first-class insurance against complete failure.

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[1] "The term 'water requirement' is used . . . to indicate the ratio of the weight of water absorbed by a plant during its growth to the weight of dry matter produced." (Briggs, L. J., and Shantz, H. L. The water requirement of plants. 1.—Investigations in the Great Plains in 1910 and 1911. U. S. Dept. Agr., Bur. Plant Indus. Bul. 284, p. 7, 1913.

The plant-breeding work here reported has been conducted on the United States experiment farms at Newell, S. Dak., and Akron, Colo. At Akron the average annual precipitation from 1908 to 1914, the seven-year period covered by these investigations, was 17.66 inches; at Newell the average was 13.03 inches for the same period. The average seasonal rainfall (April to August, inclusive) was 11.33 inches at Akron and 8.20 at Newell.

The annual and seasonal rainfall for each year is shown in Table I.

TABLE I.—*Annual and seasonal rainfall at Newell, S. Dak., and Akron, Colo., from 1908 to 1914, inclusive.*

Period and location.	1908	1909	1910	1911	1912	1913	1914	Average.
Annual:	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Newell, S. Dak.	14.16	17.73	12.55	6.74	16.09	12.53	11.39	13.03
Akron, Colo.	16.63	22.46	17.36	14.51	20.73	16.35	15.58	17.66
Seasonal:								
Newell, S. Dak.	8.46	13.30	7.19	3.78	10.87	5.94	7.86	8.20
Akron, Colo.	11.26	13.97	12.59	7.90	13.90	7.97	11.72	11.33

It will be seen that the moisture conditions at Akron have been much more favorable than at Newell during the period specified, even when we take into consideration the greater evaporation at Akron, which reduces somewhat the effectiveness of the greater amount of rainfall.[1]

BREEDING MILLET FOR ADAPTATION TO DROUGHT.

Preliminary tests[2] showed that the smaller and earlier varieties of millet (Kursk, Siberian, and Common) were more valuable under conditions of drought than the larger and later maturing varieties (German and Hungarian). The latter were therefore discarded and a large number of individual plants which showed evidence of adaptation to drought were selected among the earlier ripening varieties. In making these selections the aim was also to secure plants having a good forage type, stooling freely, fine in texture, and leafy, combined with desirable seed habits. Simple selection, without hybridization, was the method used throughout. The original stocks of the varieties with which the work was begun showed abundant variation, and the improvement accomplished has been the result of segregating the superior strains.

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[1] For a full discussion of this subject, see Briggs, L. J., and Belz, J. O., Dry farming in relation to rainfall and evaporation., U. S. Dept. Agr., Bur. Plant Indus. Bul. 188, 71 p., 23 fig., 1 pl., 1910.

[2] Dillman, A. C. Breeding drought-resistant forage plants for the Great Plains area. U. S. Dept. Agr., Bur. Plant Indus. Bul. 196, p. 25. 1910.

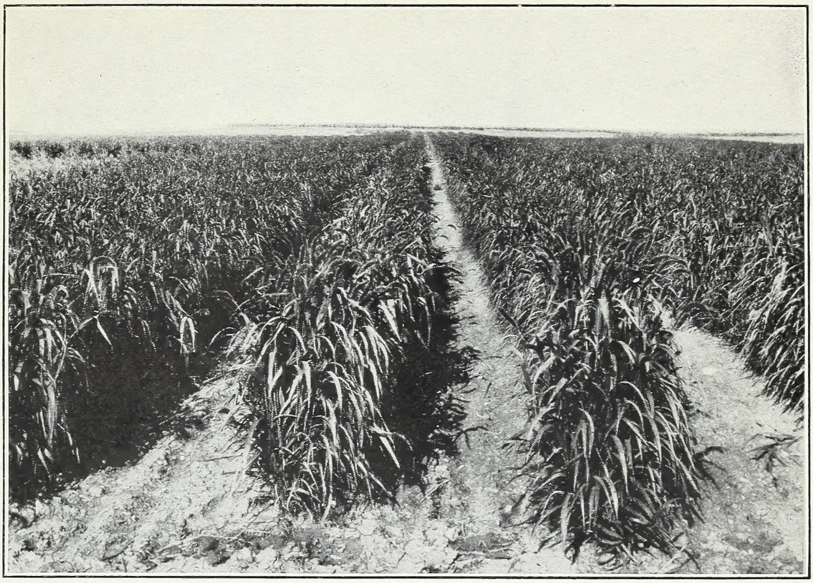

FIG. 1.—DAKOTA KURSK MILLET, SHOWING THE ERECT, LEAFY GROWTH OF THE PLANTS AND THE ERECT OR INCLINED HEADS.

Photographed at Newell, S. Dak., August 23, 1912.

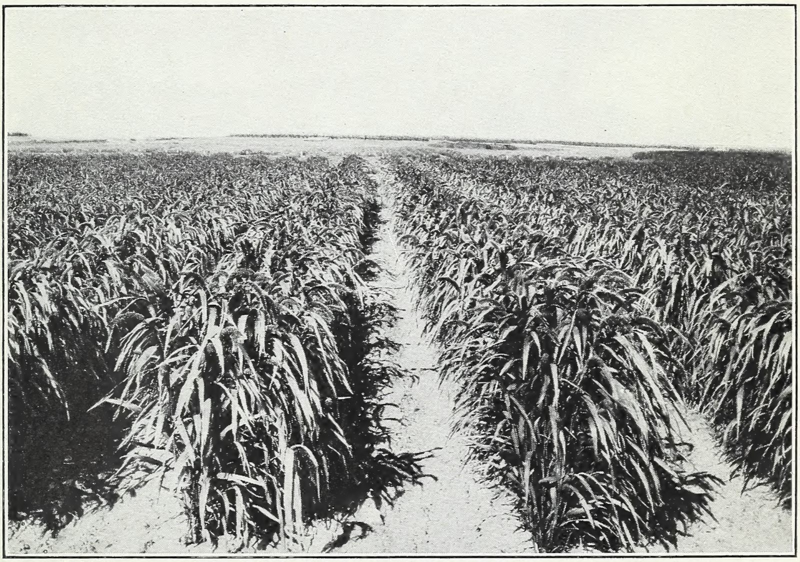

FIG. 2.—SIBERIAN MILLET (A. D. I. NO. 4—3), OF COARSER TYPE THAN THE DAKOTA KURSK AND HAVING LARGE DECLINED OR DROOPING SEED HEADS.

Photographed at Newell, S. Dak., August 23, 1912.

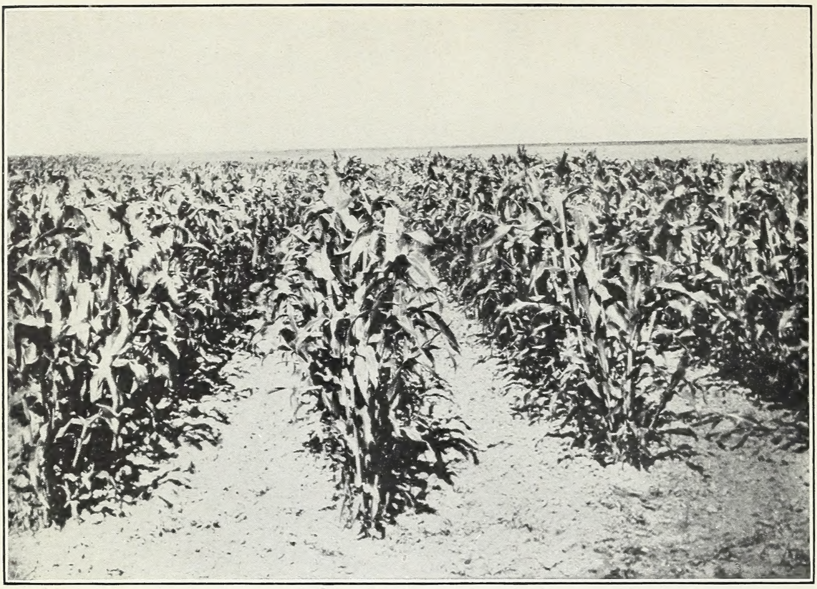

FIG. 1.—DAKOTA AMBER SORGO, SHOWING ITS COMPARATIVELY LEAFY HABIT OF GROWTH.

Photographed at Akron, Colo., July 22. 1912.

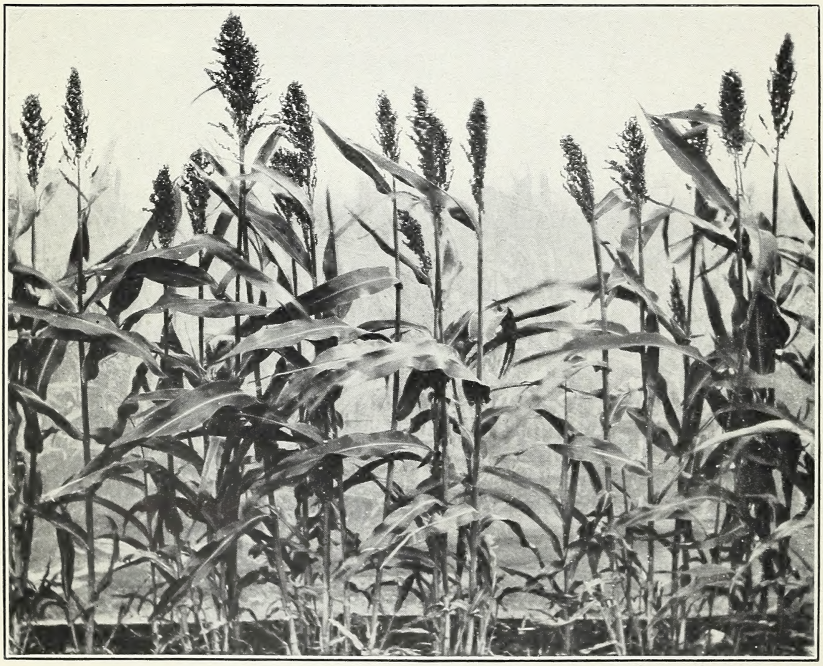

FIG. 2.—DAKOTA AMBER SORGO, SHOWING A CLOSER VIEW OF SOME NEARLY MATURE PLANTS.

Photographed at Newell, S. Dak., August 22, 1914.

Several of the selected individuals gave rise to uniform and productive strains. Comparative-yield tests of these strains, both in drilled plats and cultivated rows during several seasons, resulted in the final selection for increase and distribution of the Dakota Kursk and of the Siberian strain described in the following pages.

DESCRIPTIONS OF NEW STRAINS OF MILLET.

DAKOTA KURSK MILLET.

Dakota Kursk (A. D. I. No. 3) is the name proposed for one of the selected strains of millet which is being distributed on the northern and central Great Plains. The type is a definite one, although closely resembling in its botanical characters certain other strains of Kursk millet. The plants grow erect, or inclined when nearly ripe; the stools or culms are very numerous and small. The leaves are numerous, comparatively narrow, fine in texture, and of a distinctly lighter green than those of the other selections of Kursk millet mentioned in this bulletin. The seed head is from 2 to 4 inches long, about five-eighths of an inch thick in the middle, and tapers slightly to base and tip. It has the characteristic stiff bristles of other millets, but the head is close and firm, so that the seed does not shatter easily. The color of the seed coat of mature seeds is nearly apricot orange, as represented by Ridgway.[1]

This variety has not always ranked first among the writer's selections in respect to hay production, but it is one of the best in quality of forage and in habit of growth, and it is also one of the most productive, both of hay and of seed. (See Pl. I, fig. 1.)

SIBERIAN MILLET.

Siberian millet (A. D. I. No. 4–3) is a larger type of millet than the Dakota Kursk, and therefore produces a somewhat larger tonnage of hay under favorable moisture conditions. The plants grow fairly erect or slightly spreading. The stems are coarser and less numerous than in the Kursk variety, and often have an olive-brown coloring of the basal internodes. The leaves are broad, rather thick, and comparatively coarse. (See Pl. I, fig. 2.) The seed head is 3 to 5 inches long, cylindrical, and much less compact than in the Kursk millet, usually declined or drooping. The seeds are the same color as in Dakota Kursk, apricot orange, but the shade is paler.

The results of plat tests at Akron, Colo., and Newell, S. Dak., show that, on the average, Siberian millet (A. D. I. No. 4–3) will produce a slightly larger tonnage of hay than Dakota Kursk. The latter, however, produces a more desirable quality of hay, being finer, more leafy, and possibly more nutritious, as is indicated by the results of chemical analyses. The seed production of Dakota Kursk is also better, especially in dry seasons, than that of the Siberian strain. Under more humid conditions this millet may be the more profitable variety, but in the Great Plains it is probable that Dakota Kursk will give better average results.

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[1] Ridgway, Robert. Color Standards and Color Nomenclature, pl. 14. Washington, 1912.

COMPARATIVE YIELDS OF SELECTED STRAINS OF MILLET.

In testing the comparative value of the progeny strains of millet, two methods of planting have been used. These were (1) ordinary plats of one-tenth or one-twentieth acre in size, with the seed drilled at the rate of 20 pounds per acre, and (2) cultivated rows 8 rods long, seeded at the rate of 2 pounds per acre. In most cases the plats have been planted in duplicate or triplicate, and the rows in all tests have been planted in duplicate.

At the Akron Field Station the two varieties of millet which have given the largest yields are Siberian and Kursk. These varieties have been represented in the comparative tests by uniform strains selected for drought adaptation. The two strains of Siberian millet have given slightly higher yields than the six strains of Kursk millet, both in drilled plats (Table II) and in cultivated rows. Of the strains of Siberian millet, A. D. I. No. 4–3 is a better hay type than No. 4–5, being finer and more leafy.

TABLE II.—*Yields of millet strains in drilled plats at Akron, Colo., from 1910 to 1914, inclusive.*

Variety and number.	Yield of air-dry hay per acre (pounds).					
	1910[1]	1911[2]	1912[2]	1913[3]	1914[2]	3-year average, 1911–1913.
Dakota Kursk, A. D. I. No. 3	5,320	3,700	5,830	4,420	5,300	4,650
Dakota Kursk, A. D. I. No. 3–2		3,500	5,990	4,700		4,730
Kursk, A. D. I. No. 5	5,080	3,300	5,820	4,500	5,580	4,540
Kursk, A. D. I. No. 10	4,340	3,430	5,470	4,010		4.300
Kursk, A. D. I. No. 10–3		3,370	5,980	4,480		4,610
Kursk, A. D. I. No. 13–3		3,430	5,755	4,420		4,540
Average	4,910	3,460	5,810	4,430	5,470	4,560
Siberian, A. D. I. No. 4–3		4,220	6,020	4,580	5,710	4,940
Siberian, A. D. I. No. 4–5		4,340	6,170	4,560		5,020
Average		4,280	6,100	4,570	5,710	4,980

[1] Yields based on single plats.
[2] Yields based on the average of duplicate plats.
[3] Yields based on the average of triplicate plats.

Among the strains of Kursk millet, A. D. I. No. 3 and a selection from this strain, A. D. I. No. 3–2, have given the highest yields at Akron. (See Table II.) These two strains are practically identical in type of plant and have been given a common name, Dakota Kursk. No. 3–2 has given somewhat the greater yield, both at Akron and at Newell, and hereafter the strain bearing this number will be used as far as possible for distribution to farmers.

At the Belle Fourche station, Newell, S. Dak., in drilled plats, Siberian millet, A. D. I. No. 4–3, produced larger yields than the strains of Kursk millet in 1912 and 1914, while in 1913 the yield was about the same. In cultivated rows, the highest yielding strain in 1912 was Dakota Kursk No. 3. At the Ardmore (S. Dak.) Field Station in 1914 the Siberian strain, No. 4–3, yielded slightly higher than the Kursk strains. At the Mandan (N. Dak.) Field Station the yields of Dakota Kursk millet and Siberian No. 4–3, based on the average of triplicate plats, were exactly the same, 4,300 pounds per acre. (See Table III.)

TABLE III.—*Yields of millet hay in drilled plats at Newell, S. Dak., 1912 to 1914, inclusive, and at Ardmore, S. Dak., and Mandan, N. Dak., in 1914.*

Variety and number.	Newell, S. Dak.			Ardmore, S. Dak.	Mandan, N. Dak.
	1912[1]	1913[2]	1914[2]	1914[2]	1914[3]
Dakota Kursk:	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
A. D. I. No. 3	6,410	3,040	1,300	2,080	4,300
A. D. I. No. 3–2		3,250			
Kursk:					
A. D. I. No. 5	6,320	3,650	1,500	2,000	4,240
A. D. I. No. 10	6,400	2,950			
A. D. I. No. 13–3	6,350	3,750			
Average	6,370	3,330	1,400	2,040	4,270
Siberian, A. D. I. No. 4–3	6,850	3,300	2,000	2,170	4,300

[1] Yields based on single plats.
[2] Yields based on the average of duplicate plats.
[3] Yields based on the average of triplicate plats.

SEED PRODUCTION OF MILLET.

Millet of the foxtail type (*Chaetochloa italica*) is grown chiefly for forage, and yet some varieties, especially the Kursk, produce very good crops of seed. When millet is grown for seed in the Great Plains it is generally safest, in order to insure a crop, to plant in cultivated rows. When planted in this way Kursk millet has seldom failed to produce a profitable crop. Table IV gives a summary of the yield of seed at Akron, Colo., and Newell, S. Dak. The lowest yield recorded at Akron was in 1910, when the average from all strains of Kursk millet was at the rate of 17.8 bushels per acre. In 1912 the six Kursk strains yielded at the rate of nearly 36 bushels per acre. At Newell in 1912 five strains of Kursk millet yielded at the rate of 21.7 bushels per acre and the two strains of Siberian millet at the rate of 14.3 bushels per acre.

There is a demand from commercial seed companies for pure millet seed, and it would seem that growing this crop for seed is likely to become a profitable industry in some sections of the Great Plains. It can, no doubt, be raised more economically on the cheaper lands of the Great Plains than on the more expensive lands of the prairie region farther east. There is certainly every reason why farmers in the Great Plains should grow all the seed required for their own planting, and it is not unlikely that much of the eastern demand for millet seed can be supplied from this region.

TABLE IV.—*Seed yield of millet strains at Akron, Colo., and Newell, S. Dak., in bushels per acre.*[1]

Variety and number.	Akron.				Newell.	Average.
	1909	1910	1911	1912	1912	
Dakota Kursk:						
A. D. I. No. 3	29.5	....	32.0	28.4	24.3	28.6
A. D. I. No. 3–2	....	16.6	30.5	39.0	24.4	27.6
Kursk:						
A. D. I. No. 5	34.0	....	26.0	39.0	18.8	29.5
A. D. I. No. 10	28.5	....	31.0	36.3	17.7	28.4
A. D. I. No. 10–3	....	20.4	31.0	36.5	....	29.3
A. D. I. No. 13–3	....	16.4	23.0	35.8	23.4	24.7
Average of Kursk strains	30.7	17.8	28.9	35.8	21.7	27.0
Siberian:						
A. D. I. No. 4–3	....	24.4	20.5	37.8	15.2	24.5
A. D. I. No. 4–5	....	20.4	24.0	39.8	13.4	24.4
Average of Siberian strains	....	22.4	22.3	38.8	14.3	24.5

[1] For seed production the millets were grown in cultivated rows 3½ feet apart. Fifty pounds of seed is considered a bushel.

BREEDING SORGO FOR ADAPTATION TO DROUGHT.

In breeding sorgo[1] it has been the object to secure a type which matures early, in order that it may be grown with greater profit in the northern Great Plains, where at the present time very little sorgo is grown. The drought resistance of sorgo and its heavy forage production make it a valuable crop for the dry-land farmer, while its many varieties and types, which cross-fertilize readily and are extremely variable, offer great opportunities for the plant breeder in the improvement of the crop.

The sorgo-breeding work described in this paper was begun with an early strain of the Minnesota Amber type, known as South Dakota No. 341. The original seed of this strain was noted by Prof. W. A. Wheeler at the Highmore (S. Dak.) substation in 1903, where it was being grown under the name "Montana." The variety was extremely variable and contained a few very early and desirable types. Individual plants representing these types were selected and several more or less uniform strains were developed from these. Comparative-yield tests of these strains in cultivated rows at Newell, S. Dak., and Akron, Colo., have resulted in the selection of one of the best for increase and distribution on the northern Great Plains. This is the earliest and most distinct of the selected types and is described in this paper under the name Dakota Amber.

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[1] The term "sorgo" is here used in accordance with the practice established by Mr. Carleton R. Ball (The history and distribution of sorghum, U. S. Dept. Agr., Bur. Plant Indus. Bul. 175, p. 8, 1910) to designate the saccharine as distinguished from the grain types of sorghum.

DAKOTA AMBER SORGO, A NEW FORAGE VARIETY.

The name Dakota Amber is here proposed for the strain A. D. I. No. 341–10–4, which is a selection from Minnesota Amber (S. D. No. 341). This strain of sorgo is of a distinct type and comes true when not crossed with other forms of sorghum. It most nearly resembles the Minnesota Amber type, but it is more dwarf in habit of growth and is 15 days earlier in maturing than the Minnesota Amber variety. The plants are slender, $4\frac{1}{2}$ to 5 feet high, bearing 3 to 5 stems nearly equal in height; leaves 7 or 8 per stem; panicle rather compact, 5 or 6 inches long; seed oval, cinnamon color;[1] glumes black, shining, with slight hairiness at base.

This variety is valuable on account of its earliness, excellent forage, and good seed production. It will mature perfectly at the Belle Fourche Experiment Farm, Newell, S. Dak., in 90 days. This station is in latitude 44° 42′ N., and has an altitude of 2,900 feet. It is probable that this variety will mature wherever Northwestern Dent corn will ripen.

The forage, on account of the fine stems and comparative leafiness, is of excellent quality. The stems are uniform and equal in height. Each stem produces a seed head, or panicle, which makes a ripening field very uniform in appearance. The leafy character of the variety is well shown in Plate II, figures 1 and 2.

In the latitude of Kansas and Nebraska the larger types of sorgo (Red Amber, Orange, and ordinary Minnesota Amber) will, no doubt, produce larger crops than this dwarf variety (Dakota Amber). Throughout the Dakotas and Montana, however, and at higher altitudes farther south in the Great Plains, this early variety is likely to prove a valuable addition to the few forage crops grown there. The yield of this variety can be increased, where drought is not too severe, by planting somewhat thicker than is recommended for the larger varieties. Thicker planting compensates for the small size of the individual plants.

The seed production of this variety is remarkably good. Under average conditions of moisture supply it will produce from 15 to 25 bushels of seed per acre. At Akron, Colo., in 1912, under rather unfavorable conditions, the yield of seed was 14 bushels per acre, while at Newell, S. Dak., on soil that was fallow the previous season, the yield in 1913 was over 28 bushels per acre. It is an easy matter, therefore, to increase the variety and secure seed for forage planting.

In perfectly clean seed of Dakota Amber sorgo there are about 26,000 seeds per pound, but in ordinary seed, which contains a large proportion of hulls, there are about 16,000 or 18,000 seeds per pound.

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[1] Ridgway, Robert. Color Standards and Color Nomenclature, pl. 29. Washington, 1912.

Allowing a germination of 75 per cent, ordinary seed will produce about one plant per linear foot of row when seeded at the rate of 1 pound per acre in rows 3½ feet apart. This dwarf form of sorgo, Dakota Amber, may be planted somewhat thicker than the larger kinds, so that 5 or more pounds per acre are recommended.

It is necessary to have sorgo nearly mature at the time of harvest, in order that the crop may have the highest possible food value. The protein and fats are present in relatively large quantity in the earlier growth of the plant, while the carbohydrates develop most rapidly in the later stages of growth. For this reason it is desirable to have a variety which will approach maturity in the region where it is grown, in order to secure the maximum food value of the crop.

TABLE V.—*Comparative yields of air-dry forage of sorgo, corn, and Sudan grass at Akron, Colo., Mandan, N. Dak., Newell, S. Dak., and Ardmore, S. Dak., from 1911 to 1914.*

[The actual yield is stated as pounds per acre; the relative yield is the ratio to that of Dakota Amber, which is taken as 100 in each case.]

Crop, variety, and strain.	Akron, Colo.						Mandan, N. Dak.	
	1911 [1]		1912 [2]		1914 [3]		1914 [3]	
	Actual.	Relative.	Actual.	Relative.	Actual.	Relative.	Actual.	Relative.
Sorgo, Dakota Amber:								
A. D. I. No. 341-10-4	5,155	100	7,480	100	5,530	100	7,570	100
Sorgo, Minnesota Amber:								
A. D. I. No. 341-2	4,600	89	8,780	117	6,880	126		
A. D. I. No. 341-13	4,420	86	6,540	87	5,860	106		
A. D. I. No. 341-5-1	5,500	107	7,850	105				
Sorgo, Red Amber	7,300	142	9,980	133	7,320	132	11,720	157
Corn, Northwestern Dent							4,210	56
Sudan grass					3,840	69	3,215	42

Crop, variety, and strain.	Newell, S. Dak.				Ardmore, S. Dak.			
	1913 [4]		1914 [2]		1913 [5]		1914 [2]	
	Actual.	Relative.	Actual.	Relative.	Actual.	Relative.	Actual.	Relative.
Sorgo, Dakota Amber:								
A. D. I. No. 341-10-4	2,150	100	3,400	100	820	100	1,670	100
Sorgo, Minnesota Amber:								
A. D. I. No. 341-2	2,770	129	4,040	119	700	85	1,660	99
A. D. I. No. 341-13	2,200	102						
A. D. I. No. 341-5-1	3,080	143						
Sorgo, Red Amber	1,500	70	3,420	101	600	73	2,600	156
Corn, Northwestern Dent	1,600	74	2,560	75			1,010	60
Sudan grass			1,570	46			890	53

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[1] The average yield of duplicate plats except in the case of Red Amber Sorgo, of which only 1 plat was grown.

[2] The average yield of duplicate plats.

[3] The average yield of triplicate plats.

[4] The yields of Dakota Amber sorgo, Red Amber sorgo, and corn were secured from single plats; the yields of the three selections of Minnesota Amber sorgo from duplicate plats.

[5] The yields secured from single plats of each variety.

Another advantage in growing this early strain is the profit to the farmer in producing his own seed. Sorgo seed costs from $2 to $5 per 100 pounds [1] when bought from seedsmen, and farmers are not likely to grow a large acreage unless they can produce their own seed. There is probably a further advantage in having locally acclimated seed. This has been shown to be true of other field crops, and it will no doubt be found to be the case with sorgo.

COMPARATIVE YIELDS OF SELECTED STRAINS OF SORGO.

The strains of sorgo developed from selected individual plants of the Minnesota Amber type of sorgo were tested during several seasons in regard to their comparative forage production and drought resistance at the Akron (Colo.) and Newell (S. Dak.) stations. The principal tests were made in plats by planting in rows 3½ feet apart, cultivating between the rows. Other tests were made by planting Dakota Amber sorgo in comparison with millet and Sudan grass in drilled plats. Red Amber sorgo (commercial seed), Sudan grass, and corn (Northwestern Dent) were included for comparison in some of the tests. The results are summarized in Table V.

At Akron the larger types of sorgo, Minnesota Amber and Red Amber, have produced greater average yields of fodder than the early dwarf type, Dakota Amber. (See Table V.) In 1913 the varieties of sorgo were not weighed separately, on account of the very poor stand secured, due to drought at planting time. A half-acre plat of Dakota Amber which was grown for increase of seed yielded at the rate of 1,675 pounds per acre of air-dry forage.

At Newell the advantage also, taking the average of all yields, has been somewhat in favor of the larger types. In 1913, on plats which had produced millet the preceding year and on which the moisture supply was consequently limited, Dakota Amber (2,150 pounds per acre) yielded more than Red Amber (1,500 pounds per acre), but less than the larger type of Minnesota Amber No. 341–2 (2,770 pounds per acre). In 1914 the mean yields of Dakota Amber and of Red Amber at Newell were the same, 3,400 and 3,420 pounds per acre, respectively, while Minnesota Amber No. 341–2 made nearly 20 per cent more, or 4,040 pounds.

In spite of the larger yield of Minnesota Amber No. 341–2 there is reason to believe that Dakota Amber is the more valuable variety. It is early and will mature seed in any season, the stools are small and are easily eaten by stock, and the fodder is relatively more leafy than the larger type. Because of its smaller size Dakota Amber may be planted more thickly than the larger sorgos. This has not been done in the tests referred to, but it would probably increase the yield of this dwarf type to plant it thicker.

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[1] Three seed companies in the Northwest quoted Minnesota Amber sorgo seed in their catalogues for 1914 at $3.50, $3.75, and $6 per 100 pounds, respectively.

YIELDS OF EARLY AND LATE TYPES OF SORGO UNDER CONDITIONS OF DROUGHT.

There is no doubt that the later and larger growing varieties of sorgo will produce a greater tonnage of forage in a favorable season than the smaller forms, but in a dry season the earlier kinds are likely to produce the larger crop. The advantage of an early variety was shown at the Belle Fourche Experiment Farm in 1913, where two types of sorgo were grown under different conditions of soil moisture. The two sorgos compared were Red Amber, which is late in maturing in this locality, and Dakota Amber, a very early variety. They were grown under two conditions of soil moisture: (1) On plats which produced millet the previous season and were entirely exhausted of any stored moisture, and (2) on plats which were fallow in 1912 and were in excellent moisture condition at the time of planting. The total dry matter produced is shown in Table VI.

TABLE VI.—*Forage production of early and late types of sorgo under conditions of limited and of ample soil moisture supply at Newell, S. Dak., in 1913.*

Variety.	Air-dry forage per acre (pounds).	
	Series A; moisture limited.	Series B; moisture ample.
Red Amber (late maturing)	1,500	7,600
Dakota Amber (early maturing) No. 341-10-4	2,150	4,500

The plats which had been in millet (series A) suffered considerably from lack of moisture and were harvested August 25, 79 days after planting, the plants having by that time reached the limit of their growth. The plats which had been fallowed (series B) contained available moisture throughout the season and were harvested September 11, 96 days after planting. At this time the seeds of Dakota Amber were fully mature, while the seeds of Red Amber were in the early dough stage. Under conditions of drought the early strain produced 43 per cent more air-dry forage, but where both were enabled to approach maturity under favorable conditions of moisture the later strain produced the larger crop by 69 per cent.

COMPARATIVE YIELDS OF SORGO, MILLET, AND OTHER ANNUAL FORAGE CROPS IN THE CENTRAL AND NORTHERN GREAT PLAINS.

The farmer will desire to know which of the two crops here discussed is the more profitable under dry-land conditions and also how they compare in value with other annual forage crops which are suitable for growing in the Great Plains. Variety tests conducted in the Great Plains region by the Office of Forage-Crop Investigations of the Bureau of Plant Industry[1] have shown that the saccharine sorghums produce much the largest tonnage of any of the annual forage crops tested. The average yield of four varieties of saccharine sorghums was 3.5 tons per acre, as compared with 1.3 tons for four varieties of foxtail millets, 1 ton for cowpeas, and 0.8 ton for field peas.

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[1] Vinall, H. N. Annual forage crops for the dry lands. *In* Jour. Amer. Soc. Agron., v. 5, no. 3, p. 176–181. 1913.

From comparative yields at Akron, Colo., it appears that sorgo is a more profitable crop than millet from the standpoint of tonnage. In Table VII is given the average tonnage production of all varieties of millet in drilled plats and all sorgos in cultivated rows at Akron from 1910 to 1914, inclusive. The figures show that each year the relative yield was larger for sorgo, its average yield having been 40 per cent higher than that of millet.

TABLE VII.—*Comparative yield of millet and sorgo at Akron, Colo., in 1910, 1911, 1912, and 1914.*

Year and crop.	Number of plats, averaged.	Pounds per acre.	Relative yield.
1910:			
Millet	10	4,950	100
Sorgo	5	7,940	160
1911:			
Millet	22	3,530	100
Sorgo	11	5,190	147
1912:			
Millet	16	5,880	100
Sorgo	14	7,890	134
1914:			
Millet	12	5,170	100
Sorgo	11	6,360	123
Average yield for 4 years:			
Millet		4,880	100
Sorgo		6,850	140

Some idea of the relative yield of the new strains of sorgo and millet described in this paper, as compared with other types of annual forage crops, can be had from the data presented in Table VIII.

TABLE VIII.—*Yield of air-dry forage (in pounds per acre) of Dakota Amber sorgo, Red Amber sorgo, Dakota Kursk millet, Sudan grass, and Northwestern Dent corn at Newell, S. Dak., Akron, Colo., Ardmore, S. Dak., and Mandan, N. Dak.*

Location and crop.	Drilled plats.	Cultivated rows.	Average.	Relative, Dakota Amber = 100.
Newell, S. Dak., 1913:				
Dakota Amber sorgo		3,325	3,325	100
Red Amber sorgo		4,550	4,550	137
Millet	3,250		3,250	98
Sudan grass	2,650		2,650	80
Corn		2,600	2,600	78
Newell, S. Dak., 1914:				
Dakota Amber sorgo		3,400	3,400	100
Red Amber sorgo		3,420	3,420	100
Dakota Kursk millet	1,300	2,080	1,690	50
Sudan grass	2,300	1,570	1,935	57
Corn		2,560	2,560	75
Akron, Colo., 1914:				
Dakota Amber sorgo		5,530	5,530	100
Red Amber sorgo		7,320	7,320	132
Dakota Kursk millet	5,360		5,360	97
Sudan grass	4,380	3,840	4,110	74
Ardmore, S. Dak., 1914:				
Dakota Amber sorgo		1,670	1,670	100
Red Amber sorgo		2,600	2,600	156
Dakota Kursk millet	2,080		2,080	125
Sudan grass	575	890	735	44
Corn		1,010	1,010	60
Mandan, N. Dak., 1914:				
Dakota Amber sorgo		7,570	7,570	100
Red Amber sorgo		11,720	11,720	155
Dakota Kursk millet	4,300		4,300	57
Sudan grass	3,140	3,215	3,180	42
Corn		4,210	4,210	56

In comparing Dakota Amber sorgo and Dakota Kursk millet it will be seen that the results are not consistent. At Ardmore in 1914 the yield of the millet was 25 per cent greater than the sorgo, while at Newell in 1914 the millet produced only one-half as much forage as the sorgo. At Newell in 1913 and at Akron in 1914 there was a slight difference in yield in favor of the sorgo. It should be noted, however, that Dakota Amber is not as productive in seasons of favorable moisture conditions as the larger growing sorgos. The relative yield of millet is less favorable when compared with Red Amber sorgo than when compared with the smaller and earlier Dakota Amber sorgo.

Red Amber sorgo produced a greater tonnage of fodder than Dakota Amber in each of the five tests included in Table VIII. The relative yield in 1914 of Red Amber sorgo where Dakota Amber equaled 100 ranged from 100 at Newell to 156 at Ardmore. The question arises, Will it pay the farmer on the northern Great Plains to raise Dakota Amber sorgo, in view of the higher average yields of Red Amber sorgo? It has already been suggested that the yields of Dakota Amber sorgo can no doubt be increased under favorable moisture conditions by thicker planting. It has been shown that under conditions of drought Dakota Amber is likely to produce a larger crop than Red Amber. Dakota Amber will mature in a much shorter season than Red Amber and consequently can often be used as a catch crop where earlier crops have failed. It will ripen seed much farther north than Red Amber and the grower can therefore be certain of raising his own seed. These advantages of Dakota Amber sorgo seem to balance somewhat the disadvantage of lower average yields as compared with those of Red Amber.

In all the tests Sudan grass has been less productive than Dakota Amber sorgo, the relative yield where Dakota Amber equals 100 ranging from 42 at Mandan in 1914 to 80 at Newell in 1913.

Corn has produced less fodder than Dakota Amber sorgo. The relative yield at Newell in 1913 was 78, in 1914, 69; at Ardmore in 1914, 69; at Mandan in 1914, 56. The comparative yield of sorgo and corn fodder at Newell is discussed later.

It will be seen that in nearly every case the yield of sorgo is greater than that of corn, millet, or Sudan grass, and from the standpoint of tonnage alone sorgo must be considered the most desirable crop.

In comparing the yields of the three crops, millet, Sudan grass, and corn, it will be seen that in all tests except at Newell in 1914 millet has outyielded Sudan grass and corn.

COMPARATIVE YIELDS OF SORGO AND CORN FODDER AT NEWELL FROM 1908 TO 1914

The Office of Dry-Land Agriculture of the Bureau of Plant Industry has used an early strain of sorgo in its rotation experiments at the Belle Fourche station and has furnished the writer with the results of yields secured from 1908 to 1914, inclusive. The strain of sorgo used from 1908 to 1910 was of the Minnesota Amber type (S. Dak. No. 341), which is the parent stock from which the selections mentioned in this bulletin were made. In 1912, 1913, and 1914 S. Dak. No. 341–13, a selection from this strain, was used instead of the original stock. The results of yields from two closely adjacent and comparable plats of corn are given for comparison. These results are shown in Table IX.

It will be seen that where forage is the main consideration it would be much more profitable to grow sorgo than corn, for the total yield of sorgo is one-half more than that of corn. It should be considered, however, that the corn produced an average annual yield of grain of 6½ bushels per acre, which helps to compensate for the lower total weight of the crop. In most cases the sorgo also was nearly ripe when the crop was harvested and would probably have produced a yield of seed equal in value to that of the corn, although no records of the seed yield were taken.

TABLE IX.—*Comparative yield (in pounds per acre) of air-dry sorgo and corn fodder at the Belle Fourche station, Newell, S. Dak., for 1908 to 1914.*[1]

Year.	Sorgo.[2]	Corn.[2]	Relative yield of sorgo, corn=100.
1908	3,270	3,090	106
1909	5,920	3,230	183
1910	3,360	1,990	169
1912	4,100	3,870	106
1913	3,400	1,490	228
1914	1,725	725	238
Average for seven years	3,110	2,060	151

[1] No crop was planted in 1911 on account of the extreme drought of that year.
[2] Average of two rotation plats.

Corn is grown to a considerable extent in the northern Great Plains. In a favorable season a fair yield of grain is obtained, and even in a dry season some fodder will be secured. Corn is often planted for fodder alone. There is no doubt, however, that sorgo is a more profitable crop to grow where forage is the main consideration, not only on account of the higher yield of sorgo but also on account of its excellent feeding value.

WATER REQUIREMENT OF MILLET AND SORGO.

An important factor in the adaptation of millet and sorgo to conditions of drought is the low water requirement of these crops. This is a factor of special importance in the Great Plains, where the rainfall is limited and the relative water consumption of crops is in general much higher than in the more humid sections of the country. In humid regions crops are selected without regard to their water economy, but in the drier sections of the country those crops which show a low water requirement are the most likely to mature in years of deficient rainfall.

In the water-requirement measurements of Briggs and Shantz[1] at Akron, Colo., they have found that millet and sorgo are the most efficient in the use of water of any of the numerous crops compared at that place. In their summary of water-requirement determinations in 1911, 1912, and 1913 (table 34, op. cit.), the authors mentioned give the water requirement of Dakota Kursk millet (S. P. I. No. 34771) as 265 and that of Minnesota Amber sorgo (A. D. I. No. 341–13) as 305. The average water requirement of 11 varieties of corn was 368, of 7 varieties of wheat 513, and of 4 varieties of alfalfa 831. On this basis, the water required to produce 100 pounds of dry matter in Dakota Kursk millet would produce only 87 pounds of Minnesota Amber sorgo, 72 pounds of corn fodder, 52 pounds of wheat (grain and straw), and 32 pounds of alfalfa hay. The results confirm the experience of farmers, who find that sorgo and millet are among the most dependable crops grown in the Great Plains.

In 1912 the water requirement of Dakota Kursk millet was 187, being "the lowest water requirement so far recorded for any crop at Akron." In comparison with other crops this was a remarkable showing. German millet had a water requirement of 248, the proso millets 207, Red Amber sorgo 237, corn 280, Sudan grass 359, and alfalfa 659. The water required in 1912 to produce 100 pounds of Dakota Kursk millet would produce only 28 pounds of alfalfa, 52 pounds of Sudan grass, 67 pounds of corn fodder, 79 pounds of Red Amber sorgo, and 75 pounds of German millet.

WATER REQUIREMENT OF SELECTED STRAINS OF MILLET AT NEWELL.

The plant breeder who is working for increased drought resistance should determine the relative water requirement of his selected strains, as the method is a simple and comparatively rapid one and the differences, if significant, afford one of the best indications of differences in adaptability to drought conditions.

In 1912 and 1913 determinations were made of the water requirement of two strains of Kursk millet, Dakota Kursk (A. D. I. No. 3) and Kursk (A. D. I. No. 13–3), in comparison with a strain of Siberian millet (A. D. I. No. 4–3). In 1912 common millet also was included in the experiment. In 1914 only Dakota Kursk and Siberian millet (A. D. I. No. 4–3) were compared. The water requirements were as shown in Table X.

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[1] Briggs, L. J., and Shantz, H. L. Relative water requirement of plants. *In* Jour. Agr. Research, v. 3, no. 1, p. 1–63, 1 fig., pl. 1–7, 1914.

TABLE X.—*The water requirement (mean of 6 pots) at Newell, S. Dak., of selected strains of millet in comparison with a commercial variety.*

Variety and number.	Water requirement.		
	1912	1913	1914
Dakota Kursk (A. D. I. No. 3)	239±3	293±3	311±11
Kursk (A. D. I. No. 13-3)	246±3	329±3	....
Siberian (A. D. I. No. 4-3)	244±4	326±2	303±7
Common millet	316±4	....	....

The results of these determinations at Newell show no consistent differences among the selected strains. The two strains of Kursk millet and Siberian millet gave the same water requirement within the limits of experimental error in 1912, but in 1913 there was a difference in favor of Dakota Kursk of 36±4 as compared with Kursk (A. D. I. No. 13–3) and 33±4 as compared with Siberian millet. In 1914 the water requirements of the two varieties measured (Dakota Kursk and Siberian, A. D. I. No. 4–3) were again practically the same. On the other hand, in 1912 all three of the selected strains had a water requirement much lower than that of common millet, a commercial variety. At Akron, Briggs and Shantz[1] found that the selected strains of millet differed in their water requirement When the entire season's growth was considered, Dakota Kursk (S. P. I. 34771) showed the lowest water requirement of the varieties and strains compared. Further comparison of the water requirement of these strains is evidently desirable.

WATER REQUIREMENT OF DAKOTA KURSK MILLET IN SOUTH DAKOTA, COLORADO, AND TEXAS.

The water requirement of Dakota Kursk millet (A. D. I. No. 3) has been measured for three years in South Dakota by the writer and in Colorado and Texas by Briggs and Shantz. The water requirement shows considerable variation, depending both upon the latitude of the locality where the measurement was made and upon the character of the season. At Newell, S. Dak. (Table XI), the water requirement was 239 in 1912, 293 in 1913, and 311 in 1914. The lowest measurement recorded was 187, at Akron, Colo., in 1912; the highest 331, at Dalhart, Tex., in 1912. The average water requirement for the three years was 256 at Akron, 281 at Newell, and 306 at Dalhart and Amarillo.

In the matter of seed production this strain of millet shows a very low water requirement. At Newell the water requirement, based on the grain, was 577 in 1912 and 661 in 1913.[2] The water requirement of Grimm alfalfa at the same place was 735 for these two years. It will be seen, therefore, that millet produced grain with the use of less water than was used by alfalfa in the production of hay.

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[1] Briggs, L. J., and Shantz, H. L. Op. cit., p. 38, 58.

[2] At Akron in 1912, Briggs and Shantz (op. cit., p. 26) obtained the remarkably low figure of 483 for the water requirement for seed production of Dakota Kursk millet (S. P. I. 34771).

TABLE XI.—*Water requirement of Dakota Kursk millet (A. D. I. No. 3) at Newell, S. Dak., Akron, Colo., and Dalhart and Amarillo, Tex.*

Place and year.	Water requirement based on—	
	Grain.	Total dry matter.
Newell, S. Dak.:		
1912	577±18	239±3
1913	661±6	293±3
1914		311±11
Average		281±4
Akron, Colo.:		
1912	483±11	187±1
1913		286±4
1914	1,074±38	295±2
Average		256±2
Dalhart, Tex.:		
1912		331±2
Amarillo, Tex.:		
1913	644±10	269±2
1914	1,005±19	318±4
Average		306±2

CONCLUSIONS.

It has been the experience of old settlers in the Great Plains that successful farming in this region must include the raising of live stock. This requires the production of forage crops under cultivation, since, except in sand-hill regions and along the watercourses, the native grasses do not grow tall enough for hay. The native "short grasses" that cover the Plains usually produce sufficient feed for summer pasturage, but cultivated crops must be depended upon for winter feeding. In the northern Great Plains certain perennial crops—alfalfa and brome-grass—give good results, but farther south the annual forage crops, millet and sorgo especially, are the most dependable. These two crops have proved to be adapted to drought and capable of producing profitable crops where the annual rainfall averages from 12 to 18 inches.

The drought adaptation of millet is due largely to its early maturity and low water requirement, while sorgo has, in addition to these two valuable characteristics, a remarkable ability to endure drought. Even though its growth is severely checked during a period of drought, it will resume growth upon the return of favorable conditions. It has been shown that millet and sorgo require less water for the production of a ton of hay than any other crops that have been tested in the central Great Plains.

The Kursk and Siberian varieties of millet have given larger yields of hay than other varieties of this crop tested in the northern Great

Plains. In each of these varieties a strain has been selected which is believed to be much superior to the parent stock. Dakota Kursk millet, one of these selections, is an early variety of good forage type. The plants are 30 to 34 inches high when mature, have many rather fine stems, and many leaves. The yield of hay from this variety has averaged 2¼ tons per acre at Akron, Colo., and 1¾ tons at Newell, S. Dak. In seed production this variety is excellent, producing under ordinary conditions from 15 to 25 bushels per acre. The seed head is close and firm and does not allow the seed to shatter readily.

Siberian millet (A. D. I. No. 4–3) is a larger type of millet than Dakota Kursk, growing from 36 to 40 inches high. It has coarser stems and leaves and makes a somewhat poorer quality of hay. It does, however, produce a larger yield per acre than the Dakota Kursk. The seed head is much larger and less firm than in the Dakota Kursk, and the seed shatters more readily. In regions of greater rainfall this variety may be more valuable than Dakota Kursk on account of its higher yield, but for the northern Great Plains it is believed that the latter variety is the better type.

A strain of early sorgo is much needed for cultivation in the northern Great Plains, where at the present time very little sorgo is grown. A strain of sorgo has been developed by selection which is especially promising for this region and for higher altitudes farther south in the Great Plains. In favorable seasons the larger growing sorgos produce a larger tonnage than this dwarf type, but in dry seasons the latter will yield at least as heavily as the larger varieties. This type is very early, maturing seed in a period of about 90 days, and can often be used as a catch crop where other crops have failed. It produces seed freely, and the farmer can easily raise his own supply of seed for forage planting. On account of the smaller size of the plants this dwarf sorgo can very well be planted thicker than the larger growing varieties. This new variety has been named Dakota Amber sorgo.

Sorgo will probably produce a larger tonnage of fodder than any other annual forage crop of this region. At Akron, Colo., sorgo has produced 40 per cent greater yields than millet. At Newell and Ardmore, S. Dak., also the results have been in favor of sorgo. In a 7-year test at Newell sorgo has produced 51 per cent more fodder than corn. Dakota Amber sorgo has produced on the average 40 per cent more forage per acre than Sudan grass in tests at Newell, Akron, Ardmore, and Mandan.

It is believed that Dakota Kursk millet and Dakota Amber sorgo will prove valuable additions to the list of forage crops adapted to the northern and central Great Plains.

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